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A Threatened Fish Species (*Aphanius dispar*) in Saudi Arabia, A Case Study

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Abstract: The present study showed that the population density of a native fish (*A. dispar*) in the freshwater environments of Saudi Arabia is declining. It is concluded from the present investigations that *A. dispar* is not threatened by a single isolated factor, but instead faces numerous stressors that jeopardize multiple stages of their life cycle. Reduced availability of food, habitat degradation, chemical contamination, introduction of exotic species and exploitation have contributed to the decline of such native fish's abundance. Protecting fishes will help to protect aquatic biodiversity and in conservation of biological heritage of the country.

Key words: Freshwater fish, species extinction, ecosystem disturbance, environmental impact, pisces

INTRODUCTION

Saudi Arabia witnesses the presence of a number of freshwater environment in the form of springs, isolated pools and wadis. They harbor many exotic and native fish species. Alkahem and Behnke (1983), Ross (1985) and Siddiqui and Herbi (1995) have described the presence of three exotic species of *Oreochromis*, two species of *Poecila*, one species of *Gambusia* and one species of *Clarias* from these environments. They also described 18 native species and subspecies, which include *Barbus* (3 species), *Aphanius* (2 sub-species), *Garra* (9 species and subspecies), *Cyprinion* (3 specie and two sub-species) and *Acanthobrama* (1 species).

Ichthyological studies can be of significance for interpretation of the climatic and hydrographical history of the country. Fish can be a more important part of the economy by increasing the supply of proteins, providing the recreational and aesthetic values and finally as a biological control agent of various vectors.

Fishes represent one of the most imperiled groups of animals and exhibit some of the highest rate of extinction (Moyle and Leidy, 1992; Bruton, 1995; Leidy and Moyle, 1997; Richter *et al.*, 1997; Cambray and Bianco, 1998; Ricciardi and Rasmussen, 1999). Generally comprehensive management strategies are developed only for the species which are commercially or recreationally important and subject of wide-spread exploitation (Reynolds *et al.*, 2002). There are lack of management strategies for the conservation and protection of fish which are economically unimportant (Ricciardi and Rasmussen,

1999). A considerable efforts have been made to summarize the threat and conservation issue facing freshwater fishes like percids (Craig, 2000), centararchids (Koppelman and Garrett, 2002), salmonids (Lynch *et al.*, 2002), newt (Lecis and Noris, 2003) and suckers (Cooke *et al.*, 2005). Many research works have been published showing the importance and ways of conservation of fishes. Some of the recent and important from these are of Rose *et al.* (2001), Collares-pereira *et al.* (2002), Dominguez-Dominguez *et al.* (2002), Walters *et al.* (2003), Bart and Keckeis (2004), Feyrer *et al.* (2004), Hoekstra *et al.* (2005) and Dudgeon and Smith (2006).

Both public and institutional awareness of importance of protecting the natural environments has increased in several countries during last few decades, little progress towards understanding the causes and remedies of declining population of native fish species, *Aphanius dispar*, in the different environments has been made. No specific conservation measures have been taken because of the lack of data to address this problem. The only organization in Saudi Arabia, National Commission for Wildlife Conservation and Development (NCWCD) established in 1986 has made some efforts to instill an environmental conscience and protection of the endangered fish and other animal species. Causes of decline of the fish population and reasons of their protection and conservation are discussed in this study. In the present study an attempt is made to suggest priorities for action aimed at identifying and mitigating the main threats to killy fish (*Aphanius dispar*) in the central and eastern part of kingdom of Saudi Arabia with ultimate goal of restoring the fish's stock in the region.

MATERIALS AND METHODS

Study areas: The study area includes Wadi Haneefah stream (Riyadh), Water canals (Al-Hasa), Irrigation canal (AL-Kharj) and some small lakes (Layla Afflaj). All these habitats were harboring *Aphanius dispar*, a native fish and some introduced fishes.

Wadi Haneefah extends from North of Al-Uyaynah to Southeast of Al-hair city with an approximately 110 km catchments area (Fig. 1). The main source of water for this stream is seasonal rainfall, but the urban and agricultural development has led to disposal of considerable sewage effluent and agricultural runoff. The depth of water generally measures around 2 m. At certain areas large shallow patches of water are formed. Due to the establishment of a permanent flow of water, a luxuriant flora has developed in the main channel and on the banks of stream. Four different stations (1-4) were established for making the observations.

In Al-Hasa the main canals D1 and D2 (Fig. 2) extends from the North of Al-Hasa and passes in the West-South direction (Fig. 2). It runs (D1) approximately 50 km and gives rise many small branches and irrigates around eight thousands hectare (8000 H) of lands. The width of canal ranges between 6.5-9.5 m with an average depth of 1.5 m. D2 is comparatively smaller. Six stations (four at D1 and two at D2) were marked for the observations of abundance of different species.

There are some seasonal and perennial canals with certain cemented tanks at Al-Kharj which were harboring a good population of fishes including *Aphanius dispar*.



Fig. 1: Sampling stations (1-4) in Wadi Haneefah stream

The source of water for these were the seasonal rainfall and continuous pumping of ground water. At Lyla Aflaj are small pools or lakes. The population density of different species found in these pools of water were monitored for three years.

A regular survey (half yearly) of these environments were made for a period of three years (January, 2004 to December, 2007) and a subjective estimation of population of different species were made. An average populations of these species are given in Table 1.

POPULATION DENSITY

Different species of *Aphanius* were recorded from Palestine, Iraq, near the Gulf of Iran, Dead Sea, Africa and Northwestern region of India living in freshwater and brackish water (Alkahem and Behnke, 1983). The only species of this genus (*Aphanius dispar*) is found in Yemen (Trewavas, 1941). This fish is also present in the Eastern part of Saudi Arabia, Al-Kharj, Riyadh and several springs of Khaybar. This small, non-game, fish is almost totally ubiquitous in all bodies of freshwater where it occupies a wide range of habitats differing in stream flow, water chemistry, temperature and substrate quality (Haas, 1982). It was also common in semi stagnant or stagnant water. It is reported that this fish can tolerate a temperature ranging from 28.4-38.4°C and pH 7.4-8.0. They prefer sandy, rocky or soft detritus substrate (Haas, 1982). *Aphanius dispar* occurs in the costal drainages of Arabian peninsula and can tolerate wide range of salinity.

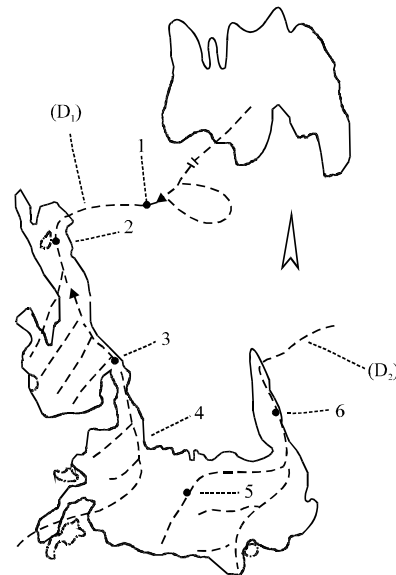


Fig. 2: Main canals (D₁ and D₂) at Al-Hasa region, 1-6 are the sampling station

Table 1: Relative abundance of different species in different environments

Fish species	Water canal Al-Kharj	Layla Afflaj	Wadi Haneefah stream				Water canal Al-Hasa					
			1	2	3	4	1	2	3	4	5	6
<i>Aphanius dispar</i>	+	+	+	+	+	+	+	+	+	+	+	+
<i>Oreochromis niloticus</i>	+++	++	++	+++	++	+++	+++	+++	+++	+++	++	+++
<i>Oreochromis aurius</i>	++	-	++	++	+	++	++	++	+	++	++	++
<i>Oreochromis spp.</i>	+++	+	++	++	++	++	+++	++	++	++	++	++
<i>Poecilia latipinna</i>	+++	++	++	+++	++	+++	+++	+++	++	++	++	+++
<i>Poecilia reticulata</i>	+++	+	++	++	+	+++	+++	++	++	++	++	++
<i>Xiphophorus maculatus</i>	++	+	+	+	+	++	++	++	++	++	+	+
<i>Pteryoplichthys spp.</i>	+	-	+	+	+	+	+	+	+	+	+	+

+: Less abundance, ++: More abundance, +++: Most abundance, -: Absence of the species

In spite of its hard nature, a regular survey (three years) of the drainages in central (Al-Kharj and Riyadh) and Eastern (Al-Hasa) region indicated a gradual decline in the population of this species in all the drainage or canals visited (Table 1). It is also noticed that this species is completely vanished from the certain environments due to complete dryness of its habitats.

THREATS FACING KILLY FISH (*Aphanius dispar*)

The vast array of adaptations that have evolved in fishes whether they may be ecological, morphological, reproductive, or physiological is amazing. Due to these adaptations they have been able to take advantage of a wide range of habitats including lakes, ponds, estuaries, rivers, tide pools, springs, deserts, forests, mudflats and mountains. However despite incredible adaptive processes, dramatic reduction in the diversity of fishes due to the activities of an overgrown and over-consumptive human population have been witnessed. The decline of fish populations can be attributed to the interactions of number of factors (Table 2), the most important among them are:

Reduced availability of food: Food is essential and important for all living organisms. It is required in adequate and enough quantity for the survival and normal growth. The survival, growth and reproduction of animals including fish are influenced by the type, availability and nutritional value of food. Fishes feeding on same food items face competition (some times negatively affected or overshadowed by species feeding on the same level), forced to move or change the niche or some time their population decline owing to death, reduced growth or reduced reproduction activities. The fish *Aphanius dispar* found in the region like Al-Kharj and Laila Aflaj faced both lack of food and shortage of habitat as most of canal and pools of this area were either dried or occupied by other species of fishes.

Table 2: Relative vulnerability of *Aphanius dispar* in different regions to current threats^a

Threats	Wadi aneefah stream	Water canal Al-Kharj	Water canal Al-Hasa	Layla Afflaj lake
Exotics	+++	++	+++	+++
Environmental contaminants	+++	++	++	++
Habitat degradation (agriculture)	+++	++	++	++
Exploitation (recreational)	++	++	++	++
Eutrophication	+	+	+	+

This is a subjective evaluation, weighted towards the individual species recovered in this study. The fish shows +: Less vulnerability, ++: More vulnerability, +++: Most vulnerability to relative threat, a: Some additional threat may also exist

Loss of vegetation and habitat degradation: Terrestrial as well as aquatic environments are altered if not destroyed by vegetations. This type of alterations in animal's and fish's habitat damage the population of inhabitants (Coad, 1980). The environment of Wadi Haneefah is altered by both, overgrowth of vegetation or removal of vegetation from the shore line. Dense growth of *Naja naja* covering the water surface in most part of the stream inhibit the penetration of light and limit the movement of fish (P. Obs.). Many streams changes from extensive covered (provided by overhanging vegetation and fallen trees) to exposed streams due to the removal of vegetation by men. It is documented that removal of vegetation affect stream flow, increase erosion and turbidity and causes temperature fluctuations (Burns, 1972; Moyle, 1976). Generally, fish show negative correlation with turbidity and modification in habitat. This may be a reason for declining of the population of *Aphanius dispar* in Wadi Haneefah stream. Habitat alteration is number one cause of declining fish populations. Alterations of habitats comes in many different forms including modifications in substrate types above bottom structure, channelization, dam construction, watershed perturbation, the filling-in-of wetland and ever increasing demand of water. This results in direct fish population losses due to mortality or reproductive failure or indirect losses due to hybridization or loss of genetic diversity.

Declining of population of *Aphanius dispar* was noticed in Alkharj, Laila Aflaj, Al-Hasa and in Riyadh areas. Drying or desiccation of pools, springs and other water bodies be a reason for such decline. Pumping of water from pools and drilling of wells to meet the increasing demands of water may be the reason for this drying and indirectly affect the aquatic fauna and fish's populations by changing the environments.

Economic developments and exploitation: A threat to fish fauna is overexploitation of larger food and aquarium fishes. The shrimps stock in the Arabian Gulf has been depleted severely and conservation measures for their recovery have been enforced because it is most economically important fishery in the Gulf. Generally in developing countries capture of freshwater fishes for food is long tradition, but tended to concentrate on larger streams, on larger scale on larger fishes during the dry season. In many countries the population of some fish species decreased due to the increased demand of fish protein and new methods employed for catch. Indiscriminate catch of the fish by explosives and poisons kill more fish than the individual actually keep for consumption. The population of *Aphanius dispar* in the Wadi Haneefah and in certain streams in Al-Kharj and Al-Hasa region may be related to over exploitation as aquarium fishes and habitat alterations by human. Unmanaged fishing and pollution have raised concern over the habitat damage they cause.

Introduction of exotic species: Exotic species have a negative impact on endemic species in variety of ways. In Saudi Arabia several species of fresh water fishes have been introduced in various water bodies to increase the fish production or recreational purposes or as control agent of mosquitoes. Introduced species in the natural environments became or proved to be competitors, disease transmitter or predators to the native fish. *Gambusia affinis* not only feed on the smaller fishes but also feed on the eggs and young ones of other, resulting in decline of their population (Hurlbert *et al.*, 1972; Hurlbert, 1978; Coad, 1980). *Gambusia affinis* and *Poecilia latipinna* are a competitor to *Aphanius dispar* for food and space as they feed on similar type of food and live at same level in the environments (Al-Akel *et al.*, 1987; AL-Akel, 2003). Cooke *et al.* (2005) stated that exotic species exerts stress on native fish and causes difficulties in recovery efforts. These fishes may also introduce certain bacteria into the environments for which the native fishes are not adapted, therefore negative effects may be expected which ultimately results in reduction of

population. Introduced species may cause loss in many ways -By serious loss in economy, a competition or threat to native species, by degradation of genetic integrity caused by hybridization or by changing food web. Diminishing the native species in freshwater are pushing exploration and production of non-native species, which cause damage to endemic fauna. Experimental studies performed by Al-Johany and Yousuf (1993) revealed that the introduced species, *Gambusia affinis* certainly poses stress on native fish, *Aphanius dispar*, as they are living together at same level (surface) in the environment. So the *Gambusia* has greater capacity to tolerate adverse conditions than *Aphanius dispar*.

REASONS FOR PROTECTION OF FISH SPECIES (*Aphanius dispar*)

Ethical and aesthetical values: The fish species which needs protection in Wadi Haneefah stream and some other aquatic environments of Saudi Arabia is *Aphanius dispar*. This is a small and inconspicuous fish that has no known economic value. The conservation of none resource species of fish is a problem in Western countries and there are lack of comprehensive managements strategies for their protection (Cooke *et al.*, 2005). These fish species are being pushed to extinction without the declines are noticed (Ricciardi and Rasmussen, 1999). Saudi Arabias' setting is now disposed towards conservation of wild animals, plants and fishes. National Commission for Wildlife Conservation and Development (NCWCD) has created many sanctuaries prohibiting fishing, hunting and deplantation in many parts of the country. The criteria and guidelines of the programmes make it amendable to setting aside reserves for threatened ichthyofauna.

Every species has right to exist and they look to conservation to prevent the loss of the quality life maintained by the diversity of world. Aesthetically, wildlife and ichthyofauna specially aquarium fishes are of the interest and value to all people on earth. Many people roam the earth to see the beauty of the animals (Myers, 1979). Every species is recognized as a work of art that merits preservation by virtue of its unique status. Keeping of different species of fishes in aquarium is a growing trend in Saudi Arabia and other parts of world.

Obligations are laid down on man to husband all species for his and their mutual benefit and they should be preserved simply because it exists. The deed of person will be considered as a charity if he planted a tree or cultivated a field such that an animal or human get benefit from it.

Economic values: Fish are considered cheapest and important source of animal protein. The pressure on the fish as a source of food and their by-products are increasing due to out-breaks of world populations. Fisheries resources in Saudi Arabia and in other parts of world, not only provide the food to human but also provide job opportunities and investments. Heavy exploitation of marine fisheries are an indicator of their economic values, although very few species of freshwater fish like *Barbus arabicus* may became important for food if stocked in Saudi Arabian reservoirs. Some fish species like *Aphanius dispar* can be used as a biological agent as it feeds on filamentous algae and mosquito larvae (Hass, 1982; Al-Akel *et al.*, 1987). This species is also kept in aquarium by Saudi people (Al-Kahem, 1989). Presently the trade in aquarium fishes is considered to be one of the most profitable aquaculture enterprises in South-East Asia. So, each living species such as *Aphanius dispar* is an important and beneficial to mankind in different ways.

Ecological reasons: Some endemic species are important as environmental indicators. Potential of organisms for biological monitoring has been shown by Patrick (1972) and Bauerle *et al.* (1975). It is known that each species occupies a special niche, such as *Aphanius dispar*, is playing a unique role in its ecosystem. Loss of one species can produce a chain reaction affecting all of the other organisms which the species feed upon, those which prey on it or which it interacts in other way. The stability of ecosystem can be judged by the number of species present in it (Myers, 1979). Healthy population of species in any environment mean that there has been adequate protection of the local habitats and water quality is high.

Scientific research value: Many of the species of fishes could serve medicine through their remarkable tolerance extremes of temperatures and salinities an evolved attribute to that might assist research into human kidney disease (Myers, 1979). An other species of fish, *Aphaniua dispar* tolerates a wide range of temperatures and salinities (Al-Johany and Yousuf, 1993) could help in research relevant to environments. The presence or absence of *Aphanius dispar* or fluctuations in their number and size in a particular habitat can be used to define a base line of environmental conditions and determine the degree to which communities has been influenced by out side factors such as habitat alterations and pollutions.

APPROACHES TO CONSERVE THE *Aphanius dispar*

The strategies commonly used for conservation of freshwater fishes are appropriate for the fish described here, but individual strategy may differ in utility and applicability to the different regional issues (Table 3). Some regulations (Bow or spear) for specialized fisheries exist which tends to limit seasons and harvest quantity. Apart from regulations targeting harvest, effort to conserve fishes would be better served by developing a protected area (Crivelli, 2002) that protect or restore habitats (Poff *et al.*, 1997). The legislation or policy which directly reduces alteration to habitats or degradation of water quality would benefit the aquatic communities in that environment. The role of habitat restoration and enhancement in management and recovery will vary among different species of fish according to life history traits. Habitat restoration and enhancement activities are most appropriate and effective when focused on relieving a specified shortcoming such as recruitment bottleneck and matched in spatial scale to ecology of the target species (Lewis *et al.*, 1996). A basic knowledge of the life history of fish is also required for planning habitat restoration.

Conservation genetists have evaluated the genetic status of threatened population or use genetic information for improving captive breeding programs for imperiled species. The continued application of genetic techniques are encouraged for both understanding the natural history of the fish and development of conservation strategies for these species.

Perhaps the best approach for conserving the threatened fish may be through education and outreach. The scientists have a key role of generating public awareness and support for the conservation of fish (Cambray and Pister, 2002). Emphasis on the need to

Table 3: Relative utility and applicability of conservation strategies in different regions^a based on the subjective evaluation

Strategies	Wadi Haneefah stream	Water canal Al-Kharj	Water canal Al-Hasa	Layla Afflaj
Legislation (exploitation)	++	++	++	++
Legislation (habitat)	+++	+++	+++	+++
Protected areas	+++	+++	+++	+++
Natural flow-regime	++	++	++	+
Habitat remediation ^b	+	+	++	++
Eradication of exotic fishes	++	++	++	++
Captive breeding ^c	+	+	+	+
Education	+++	+++	+++	+++

+: Applicable, ++: More applicable, +++: Most applicable, a: Additional conservative strategies may also exist, b: Removal of environmental contaminants, c: Restricted to severely depleted stocks

conserve aquatic species diversity may promote a more accurate perception of improved appreciation for imperiled fish (*Aphanius dispar*). Outreach and general education is particularly important for such species occurring in public and private habitats.

Historically, recovery and management plans tended to focus on a single species such as those afforded protection under endangered species act, however, increasing efforts should be devoted to the development of more comprehensive and multi species approach to recovery and planning management. But it is believed that comprehensive management and conservation is rarely undertaken until the establishment of a recovery plan for an imperiled species is necessary.

It seems that the threats faced by the *Aphanius dispar* are simply the same to those faced by other species of economically important and heavily managed fish. The distribution of the fish, variety of habitat they occupy and life history they employed will present challenges for their conservation. Many other non-game fishes like suckers, cyprinids and darters mostly have similar threats to those faced by *Aphanius dispar* in Saudi Arabia. This information may be helpful and support the conservation of species with little apparent direct economic values (Cambray and Pister, 2002). All the non-game fish species will continue to face risk because of ignorance, misunderstanding and negligence. Undoubtedly, the interaction of *Aphanius dispar* with other member of the community are mutually beneficial and losses of these fishes from the ecosystem surely have a devastating effects on ecosystem structure. Cooke *et al.* (2005) suggested that a greater emphasis on the conservation of fishes without direct economic value must be placed. In failing that much of the freshwater ichthyofauna biodiversity in the world may be quietly lost over the next century (Ricciardi and Rasmussen, 1999). Skelton (2002) and Dudgeon (2003) suggested that the freshwater in developing countries (Asia, Africa) are at more risks than developed countries. Human population growth coupled with cursory understanding of freshwater fish diversity and ecology due to lack of outreach and education provide little hope for them in developing countries. The present information and other published elsewhere regarding the conservation of non-game fish will hopefully be useful in guiding the management and conservation of these fishes around the globe.

RECOMMENDATIONS

- Plans to improve the presently occupied habitats
- Plans to increase the quality of suitable habitat
- Establish a sound management plan

- Emphasis on effective management of the area which depends on co-operative management agreements with private land owners and government agencies involved in land ownership
- In as much as the states and other interested parties are engaged to develop and maintain conservation programs which meet national and international standards to better safeguard for the benefit of all citizens, the national heritage in the fisheries and wildlife
- Comprehensive ecological studies should be made.
- Status of real habitats and presence of other animal species should be checked
- Development of environmental protection law requiring elucidation and consideration of the cost, benefit trade of the proposed action
- Identification and determination of introduced species
- Control of introduction of harmful species
- Awareness of importance and urgency of species conservation in citizens
- Development of law regarding protection of threatened and endangered species from extinction

CONCLUSION

Findings of the present study showed that the population density of *Aphanius dispar* in the freshwater environments of Saudi Arabia is declining. The most affected regions are seems to be Al-Kharj and Riyadh because from the many environments of these areas the fishes are completely vanished. Anthropological activities are supposed to be the main cause of population decline. Introduction of exotic species and ecosystem alterations also have negative effects on the native species.

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